Report to the U.S. Department of Transportation

May 22, 2000

ITS STANDARDS TESTING PROGRAM

Test Report for NTCIP Dynamic Message Signs – Executive Summary

Prepared by:

Battelle Memorial Institute

Columbus, OH

R-ISTHA-DMS-V1-0

Introduction

This document, Test Report for NTCIP Dynamic Message Signs – Executive Summary, is volume 1 of a 3 volume report describing the testing of the six standards related to the Dynamic Message Sign (DMS). This volume provides a high level, executive summary of the testing procedure and results. Volume 2 provides summary detail on the testing process, test environment and conditions, analysis and evaluation results, findings, conclusions and recommendations. Volume 3 contains the complete detail repository for all questionnaires, Memorandum Of Understanding (MOU), documents, interviews, test data and information collected and examined in the planning and conduct of this testing process.

Overall Finding

The six standards tested were assessed and evaluated as suitable, effective and as contributing positively to the interoperability and interchangeability of NTCIP DMS subsystems except as discussed in the findings stated in this report. In the specific testing of 19 DMS core functions and features included in the NTCIP 2101 and 2103, there was only one exceptional finding noted with the Scheduler features.

The conclusion of the independent test team is that the DMS-specific standards 2101 and 2103 are relatively mature and have enabled two independent vendors to create fully-functional NTCIP DMS subsystems. Further, with the standards-related exceptions noted in this report, these two subsystems have the potential to be fully-interoperable and interchangeable in a mixed product operational environment."

Background

As part of the ITS Standards Test Program (ISTP) review of applicable standards, 50 standards were deemed testable. It has been the intent of the ISTP and the ITS Standards Test Team (ISTT) to test each standard for its contribution to interoperability/interchangeability via testing of a deployed ITS standards compliant system. The first device chosen for testing was the DMS. There are six National Transportation Communications for ITS Protocol (NTCIP) standards that apply to the DMS and are listed below:

1101 (TS 3.2) NTCIP – Simple Transp. Management Framework (STMF)
2001 (TS 3.3) NTCIP - Class B Profile
1201 (TS 3.4) NTCIP - Global Object Definitions
1203 (TS 3.6) NTCIP - Object Definitions for Dynamic Message Signs
2301 (TS 3.STMF) NTCIP - STMF Application Profile
2101 (TS 3.PMP232) NTCIP - Point-to-Multipoint Protocol/RS232 Subnetwork Profile

These six standards were given a pre-test evaluation to grossly assess their contribution to interoperability/interchangeability. The results of this pre-test assessment guided the development of vendor questionnaires and test procedures. It should be noted that only those aspects of the standards that specifically apply to DMSs and/or NTCIP devices were evaluated. Cases where these standards simply referred to other International Standards Organization (ISO), Request For Comments (RFC), etc. standards, were NOT evaluated.

The Illinois State Toll Highway Authority (ISTHA) was chosen as the first test site because of their willingness to facilitate the testing process and the maturity of their deployed systems. The ISTHA is currently deploying over 30 NTCIP compliant DMSs on the regional toll ways in northeastern Illinois. These signs at present come from two vendors. The ISTHA has completed acceptance testing on the two vendor's signs and control software suites using the same test procedures for both. Both suites passed these tests with exceptions. It was stated in general that the vendors attribute these exceptions to their specific interpretation of NTCIP standards generalities or ambiguities—which (apparently in this case) manifests as a deviation from the expected results contained in the test procedures.

The ISTHA also tested the control and operation of each vendor's NTCIP compliant sign with the other vendor's control software with mixed success. It is an ISTHA requirement that each vendor's roadside controller and attached DMS, from two or more vendors, be controllable by the other's center control software.

Testing Approach

As stated earlier, the results of the pre-test evaluation of the standards for interoperability/interchange-ability guided the approach and the rest of the testing processes. The approach was to collect enough data to evaluate and assess the standards in terms of three elements: suitability, effectiveness and (contribution to) interoperability/interchangeability. The testing processes needed to make that assessment, along with their relative importance to the final analysis are:

Interview product vendor/developers (40%)

This step addresses three categories of issues: issues related to exceptional conditions discovered by the vendor/developer; subjective/qualitative coverage and data collection for assessment of non-testable technical features, and verification of standards compliance prior to the commitment of resources to the test conduct.

Establish and verify standards content baseline (10%)

The ISTT qualitatively and quantitatively verified a degree of the use and conformance with the standards of interest. This process included static examination of documentation, compilation and examination of any Management Information Base (MIB) files obtained from vendor/developers, and/or examination of code-defined data structures or objects known to be derived from standards.

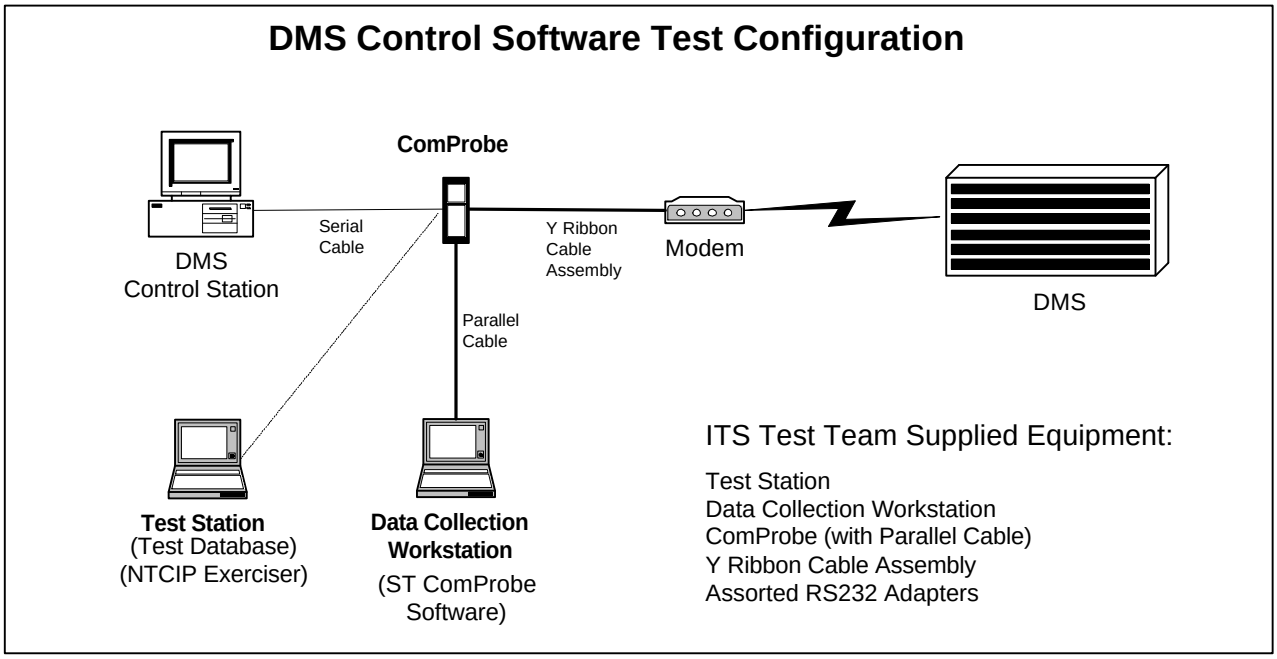
Establish Purity of External Interfaces (10%)

This test phase was performed by ISTT assisted by site communications engineering personnel and is intended to verify the basic functional connectivity and test readiness of the ITS subsystem test items. The ISTT examined and tested the external interface(s) to determine that all communications and protocols used are consistent with the use of the NTCIP standards of interest. This step examines the interface using "Sniffer" technologies with data logging (i.e., network data analyzer) to ensure that all packets exchanged are NTCIP-compliant and that there is no non-NTCIP or unexplained communications activity on the interface. This involved lower-level technical testing of physical interfaces to reduce risk and eliminate distractions prior to system-level usage. This testing process was not exhaustive, rather only what was necessary to assess the standard's suitability, effectiveness and contribution to interoperability/interchangeability.

Execute Standards Test Trials (40%)

This is the dominant time phase of the testing event. The ISTT conducted three phases of planned test trials and steps:

1. Core Functions – As defined and developed with consensus with Standards Development Organizations (SDO's), vendor/developers, and buyers.
2. Normal (Product) Features – These are features that the product currently offers at ISTHA (other than core functions).
3. Exceptions – As identified by vendors, encountered during testing, and a sample of other relevant standards (e.g. 1201, 2301, etc).



Results

Interview Product Vendor/Developers

Summarized below are some of the highlights of the general questionnaire and interview that was conducted by the ISTT at both vendor locations. The general questionnaire that was used for the interview will be included in the Volume 3 appendix. This summary does not specifically state each vendor's perspective, but provides some general comments on their experience in developing a product using NTCIP DMS standards.

1. Both the vendors stated that they had problems with Global Time. It was not tied to a particular time zone. A subsequent amendment added a Global Local Time object that remedied the problem for the most part. A residual issue is that under some circumstances (day light saving time) one could SET a time and GET a time so the values would not match. One chose to implement a Global Time DST Differential. Both vendors tried to receive guidance on daylight savings time objects and due to the lack of response chose to implement

the Amendment to 1201 that contained updates to the globalTime objects (which were still in draft format).

2. Both the vendors expressed great displeasure with the scheduler object. They stated that there is a problem to override a scheduler task without clearing the scheduler table. There is no way to enable or disable the scheduler. Both the vendors created custom objects to overcome this issue.

3. The standards provide for a single power supply on a sign. DMS signs have multiple power supplies and these are not addressed. One approach taken was to add custom object, the other was to use the Auxiliary I/O definitions in the standard (global exceptions) which provides for analog and digital I/O but does not specify exact use. This allows for different manufacturers to come up with different implementations thus creating a barrier to interchangeability.

4. Similarly, the standards provide for one photo cell (ambient light sensor). Both the vendors implemented three as was required in the ISTHA Request For Proposal (RFP), and they mentioned the fact that virtually all RFPs usually require multiple sensors. Again, one approach taken was to add custom objects, the other was to use the Auxiliary I/O definitions in the standard (global exceptions) which provides for analog and digital I/O but does not specify exact use. This allows for different manufacturers to come up with different implementations and a barrier to interchangeability.

5. Another deficiency in the standard that both the vendors commented on was that there is no capability to do graphics.

A general comment that was raised by both vendors was that there needed to be a better communications channel for obtaining information on the NTCIP standards, submitting comments and suggestions related to the standards, and obtaining help on their usage. Additionally, they found it difficult to obtain information related to referenced standards such as those developed by ISO.

Establish and verify standards content baseline

The results of the compilation of the Management Information Bases (MIBs) indicate that there are syntax errors in the Abstract Syntax Notation.1 (ASN.1) code in the MIBs available on the NTCIP web site. Preliminary investigation indicates that these are minor errors that can be corrected fairly easily, or as is more common, adjusted so that the commonly used NTCIP MIB compilers ignore them. The primary effect of these errors are that each implementer corrects them according to their own needs. This creates a de facto barrier to interoperability/interchangeability. A secondary effect is to disincline the implementers from the envisioned seamless and automated transformation of object definitions into executable software: they simply re-code the objects manually in C or C++. This introduces new opportunities for transcription errors, misinterpretations and judgment errors.

Establish Purity of External Interfaces

The external interfaces are defined in the lower level DMS standards (i.e.: those standards other than 1203 (TS 3.6) NTCIP - Object Definitions for Dynamic Message Signs and 1201 (TS 3.4 NTCIP – Global Object Definitions). Testing consisted of physically examining all interfaces and capturing data flow across the interfaces. There were no deviations from these lower level standards noted.

Execute Standards Test Trials

The results represented below are compiled from various stages of testing, analysis and documentation. They include comments based on observations during the test; analysis of the captured data flow; exceptions that were raised from vendors, which were tested; and finally any observations made by the test team while conducting the trials on core functions, exceptions or product specific feature trials.

Core Functions

The following functions were deemed essential to basic DMS operation and classified as "Core Functions":

Control Sign Display Functions
- Display a message on a sign
- Blank a sign

Create a Message Functions
- Build a new message
- Delete a message
- New line
- New page
- Flash message
- Justify line
- Justify page
- Select Font

Exceptional Sign Control Functions
- Default display condition following end of message

Scheduled Control Functions
- Configure time-base schedule
- Configure day plan
- Configure action table
- Run the schedule

Monitor Sign Display Status Functions
- View active message
- Detect pixel errors
- Identify source of message

When appropriate, each Core Function was tested using both Vendor control software and the NTCIP Exerciser software. Data flow was captured and analyzed. The result of that analysis is summarized in the below:

Total number of data packets analyzed	3049
Total number packets containing deviations that MAY cause non-interoperability/non-interchangeability	137
Total number of packets containing deviations that WILL cause non-interoperability/non-interchangeability	139

Further analysis shows that all of the deviations can be attributed to one of three issues. The issues and the number of their occurrences are shown below:

Deviations related to BER and OER discrepancies	137
Deviations related to DMS scheduler functionality	138

Deviations related to improper implementation	1

The deviations related to Binary Encoding Rules (BER) and Octet Encoding Rules (OER) discrepancies do need to be resolved, although since these standards have been deemed to be NOT strictly ITS related, this issue is beyond the scope of the ISTP. (BER describe how binary data is encoded in the packets. OER describes how octal data is encoded in the packets.) Furthermore, since the intent of the ISTP is NOT to perform acceptance or compliance testing, the single deviation due to improper implementation is also beyond the scope of the ISTP. Therefore only deviations that are within scope of the ISTP are those related to DMS scheduler functionality.

During the interview process, both vendors identified that the scheduler related portions of the 1203 (TS 3.6) NTCIP - Object Definitions for Dynamic Message Signs standard was ambiguous. Both vendors sought additional guidance from the appropriate SDO related to this issue.

Exceptions

Testing of the exceptions, those specific items identified during pretest analysis and vendor interviews that indicated potential non-interoperability/non-interchangeability issues, focused mainly on the following features:

Global Local Time Functions
Scheduler Functions
Power Supply Functions
Multiple Light Sensor Functions

Summary of Results

The complete presentation and discussion of all findings can be found in Volume 2.

There are 24 findings collected in three categories: six Interview Comments (IC), six Test Results (TR) and twelve from static Analysis of Standards (AS). These findings were rated as to their Effect (e.g., negative, neutral, positive) on the NTCIP DMS standards domain, and the Severity of that effect (e.g., critical, serious, major, minor, cosmetic).

In summary, of the 15 negative findings (see table below), there were:

0 critical,
1 Serious,
11 Major, and
3 Minor.

Note: Some of the findings affected more than one standard. In these cases, resolving the problem in one standard would resolve the problem in all standards, therefore the problem was only counted once in the criticality list above. Refer to Volume 2 for a complete description of each finding and its criticality assessment.

The following table illustrates that the exceptional negative conditions are but a small subset of all the features of the standards tested (see Volume 2 - Tab C).

	Finding Topic Area	General Issues Discussed in the Finding
Serious	Community Name Index (AS-6)	An object in the mandatory Security Conformance Group appears to be improperly coded as "not-accessible".
Major	**Scheduler (IC-1, TR-1)**	**The standard is incomplete in that it lacks a scheduler object to enable/disable the running of the schedule (a Core Function as mentioned erlier).**
	Power Supplies (IC-3, TR-4)	The standards are incomplete in that they lack support for multiple power supplies.
	Light Sensors (IC-4, TR-3)	The standards are incomplete in that they lack support for multiple illumination sensors.
	Illumination Brightness (TR-5)	The definition of brightness levels is inconsistent and ambiguous.
	External References (AS-2)	There are numerous external references to non-ITS standards that may be inconsistent.
	LAPB MIB (AS-4)	There are compatibility and usability issues with a reference to RFC 1381.
	Gauge Syntax (AS-5)	This is a syntax error in the MIB.
	Event Configuration (AS-7)	There are correctness and usability issues associated with the detection and management of events.
Minor	No Graphics Capability (IC-5)	Vendors identified this as a needed feature in the standards.
	Message CRC (TR-6)	The CRC is calculated using the message, beacons and pixel service settings. Vendors may use different default settings for these last two parameters leading to incompatible CRCs.
	Sign Housing Temperature (AS-1)	The temperature range of 0-255 ^{o}F seems in error.

Recommendations

With exceptions noted above, all of the standards related to the DMS tested to be suitable, effective and contribute positively towards interoperability/interchangeability. Overall the operational performance of the DMS Standards, when properly implemented, can lead to an effective, efficient and interoperable/ interchangeability system. However, it was determined that a DMS deployment can be implemented following the DMS standards, but remain non-interoperable. Therefore the DMS standards do not ensure interoperability/interchangeability.